Industrial Technologies Program

Development of New Geophysical Technique for Mineral Exploration and Mineral Discrimination Based on Electromagnetic Methods

New Enabling Geophysical Technology Will Augment the Identification of Economic Mineral Deposits and Yield Manifold Benefits

One of the major problems of mineral exploration is the ability to reliably distinguish between uneconomic mineral deposits and economic mineralization. While there are many geophysical methods used in the mining industry to locate economic mineral deposits, there are no reliable technologies for mineral identification and characterization.

Researchers at the University of Utah are developing a new geophysical technique for subsurface material characterization, mineral exploration and mineral discrimination, based on electromagnetic methods (EM). This new technique will be based on examining the spectral-induced polarization effects in electromagnetic data using modern distributed acquisition systems and advanced methods of 3-D modeling and inversion.

The induced polarization (IP) effect is caused by complex electrochemical reactions that accompany current flow in the earth. These reactions take place in a heterogeneous medium representing rock formations in the areas of mineralization. The quantitative interpretation of IP data in a complex 3-D environment is very challenging. The analysis of IP phenomena is usually based on models with frequency dependent complex conductivity distribution. Until recently, parameters to these models have been determined mostly in the physical lab by direct analysis of the rock samples. The proposed new geophysical technique for determining 3-D distribution of the same parameters from rock formations will be performed in the field through geophysical observations. Recovering parameters of the relaxation model will be used for the discrimination of different rocks. This will provide the ability to identify potential economic mineral deposits using remote sensing geophysical technology.

This new technique will ease additional difficulties related to inversion of IP parameters. One of the critical problems in the inversion of EM data is developing a stable inverse problem solution that can produce a sharp and focused image of the target. More focused EM images of the target can be obtained by applying a novel stabilizing function, which minimizes the area where strong model parameter variations and discontinuity occur.

The development of this new technique will also have application in old mining districts by not only detecting anomalies, but also further classifying them based on the causative sulfide mineral. The classification of these anomalies would lead to new discoveries that have so far been hidden within large district-wide anomalies. The new imaging technology will improve the ability of geophysical EM methods to visualize and predict geological anomalies in front of mining equipment.

This research will enable the mining industry to conduct resource characterization activities more efficiently and economically, imposing fewer negative impacts on the environment.

Benefits for Our Industry and Our Nation

- *Estimates annual energy savings of 16% in exploration drilling.*
- *Reduces the cost and environmental impact of exploration, using low-cost equipment.*

Applications in Our Nation's Industry

This technology will allow for better identification and characterization of economic mineral deposits in old mining districts where full economic value has not yet been fully realized.

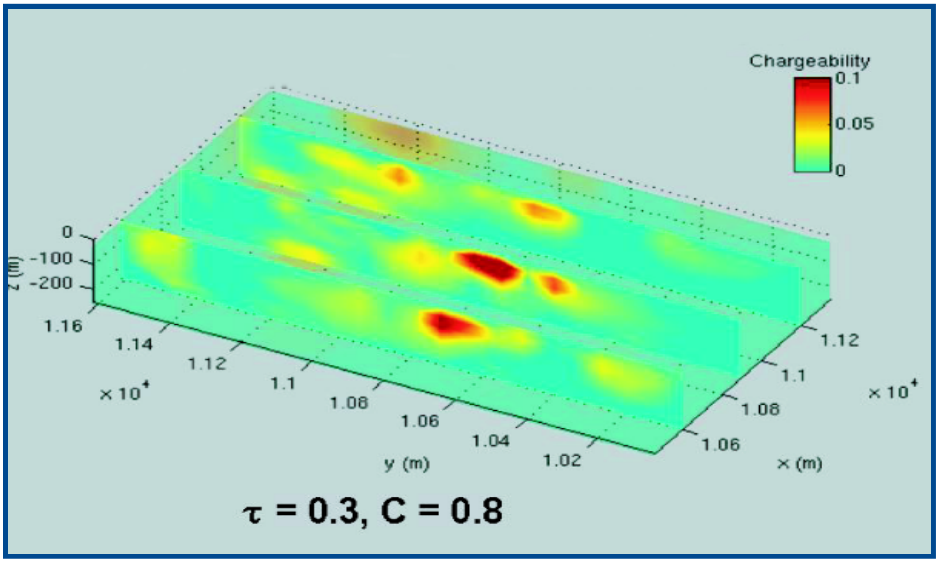
Project Description

Objective: To develop new methods and software that will result in new enabling geophysical technology for mineral exploration and mineral discrimination based on electromagnetic data.

The project will focus on five areas: First, to develop a new geophysical technique for deep sensing of rocks, minerals, and geological structures, based on the analysis of 3-D distribution of complex conductivity inferred from the observed EM geophysical data. Second, to increase the resolution, stability, and reliability of 3-D EM and IP data inversion by applying a regularization method based on focusing stabilizers. Third, to enable solutions to large-scale 3-D EM forward and inverse problems using data and inverse problem-compression techniques and parallel computing, which will speed up computations. Fourth, to improve target definition, subsurface mineral characterization, and increase investigation depth. Finally, to enhance resource identification and characterization by geophysical exploration methods, which will increase efficiency.

Milestones

- Constructing and analyzing reliable physical and mathematical models of the IP effect based on the modern developments in geophysics and geochemistry.
- Developing efficient computational systems to solve large-scale 3-D EM-IP problems, a 3-D EM-IP imaging system, and a feasibility study of the new 3-D EM-IP modeling and imaging system using synthetic data and typical mining target models.
- Conducting field surveys at designated test sites with various IP responding minerals, and collecting, processing and analyzing data at the sites to determine effectiveness.



Chargeability model obtained by the 3-D IP Inversion for the Cukurdere area

Project Partners

University of Utah
Salt Lake City, UT

Kennecott Exploration Co.
Salt Lake City, UT

BHP Billiton World Exploration Inc.
Houston, TX

Placer Dome Inc.
Denver, CO

Phelps Dodge Exploration Co.
Phoenix, AZ

Zonge Engineering and Research Org.
Tucson, AZ

A Strong Energy Portfolio for a Strong America

Energy efficiency and clean, renewable energy will mean a stronger economy, a cleaner environment, and greater energy independence for America. Working with a wide array of state, community, industry, and university partners, the U.S. Department of Energy's Office of Energy Efficiency and Renewable Energy invests in a diverse portfolio of energy technologies.

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